



Docket No. 2006-0614

PATENT

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Application of : Customer Number: 20277  
Darrell M. ERB, et al. : Confirmation Number: 4666  
Application No.: 10/791,904 : Group Art Unit: 2811  
Patent No.: 7,071,564 : Examiner: Not Yet Assigned  
Filed: March 04, 2004 :  
For: COMPOSITE TANTALUM CAPPED INLAID COPPER WITH REDUCED  
ELECTROMIGRATION AND REDUCED STRESS MIGRATION

**Certificate**

AUG 30 2006

**of Correction**

**REQUEST FOR CERTIFICATE OF CORRECTION UNDER 37 CFR 1.322**

Mail Stop COC  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450



08-24-2006

U.S. Patent & TMO/TM Mail Rcpt Dt. #30

Sir:

In reviewing the above-identified patent, a printing error was discovered therein requiring correction in order to conform the Official Record in the application.

The error noted is set forth on the two attached copies of form PTO-1050 Rev. 2-93 in the manner required by the Commissioner's Notice.

Specifically, Under "What is Claimed Is:", under column 7, line 48, change " $\beta$ -Ta " to --  $\alpha$ -Ta --, and under column 9, line 25, change " $\beta$ -Ta " to --  $\alpha$ -Ta --. Attached is a photocopy of the Amendment filed on November 28, 2005 for your immediate reference.

The change requested herein occurred as a result of printing the Letters Patent and the Certificate should be issued without expense under Rule 322 of the Rules of Practice. Accordingly, Applicants request issuance of the Certificate of Correction.

AUG 30 2006

**Patent No.: 7,071,564**

Please charge any shortage in fees due in connection with the filing of this paper to Deposit  
Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

McDERMOTT WILL & EMERY LLP



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**Date: August 24, 2006**

**Please recognize our Customer No. 20277  
as our correspondence address.**

AUG 30 2006

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 7071564  
DATED : July 04, 2006  
INVENTOR(S) : Darrell M. ERB, et al.

It is certified that an error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Under "What is Claimed Is:";

Under column 7, line 48, change "  $\beta$ -Ta " to --  $\alpha$ -Ta --, and  
Under column 9, line 25, change "  $\beta$ -Ta " to --  $\alpha$ -Ta --

MAILING ADDRESS OF SENDER:  
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Washington, DC 20005  
USA

PATENT NO.  
7,071,564

No. of add'l copies  
@ 50¢ per page

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AUG 30 2006

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 7071564  
DATED : July 04, 2006  
INVENTOR(S) : Darrell M. ERB, et al.

It is certified that an error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Under "What is Claimed Is:";

Under column 7, line 48, change "  $\beta$ -Ta " to --  $\alpha$ -Ta --, and  
Under column 9, line 25, change "  $\beta$ -Ta " to --  $\alpha$ -Ta --

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PATENT NO.  
7,071,564

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AUG 30 2006

Applicant: Darrell M. ERB, et al. Docket No. 050432-0614 Serial No. 10/791,904

Title: COMPOSITE TANTALUM CAPPED INLAID COPPER WITH REDUCED ELECTROMIGRATION AND REDUCED STRESS MIGRATION Patent No. \_\_\_\_\_

Date Sent: 11/28/2005 ☒ Hand Carried ☐ Fax ☐ Electronic ☐ Cert. of Mailing ☐ 1st Class Mail ☐ Express Mail No. \_\_\_\_\_

☐ Transmittal Letter

New Patent App ☐ Utility ☐ Design ☐ Cont. ☐ CIP ☐ Div. ☐ PCT ☐ RCE ☐ Prov

☐ Other: \_\_\_\_\_ ☐ Letter submitting \_\_\_\_\_ pages of drawings

\_\_\_\_\_ pages of Specification ☐ Req. for Approval of Drawing Amendments

\_\_\_\_\_ pages of Claims ☐ Req. for Oral Hearing

\_\_\_\_\_ pages of Abstract ☐ Not. of Appeal ☐ Appeal Brief ☐ Reply Brief

\_\_\_\_\_ pages of Formal/Informal Drawings ☐ Rule 312 Amendment/Letter

☐ Small Entity ☐ Large Entity ☐ Req. for Acknowledgement of Cited Art

☐ Declaration/Power of Attorney ☐ Issue Fee

☐ Recordation of Assignment/Security Agreement ☐ Publication Fee

☐ Information Disclosure Statement ☐ Req. for Certificate of Correction

\_\_\_\_\_ Form PTO 1449 ☐ Maintenance Fee for \_\_\_\_\_ years after grant

\_\_\_\_\_ copies of cited references ☐ Fee Address Indication Form

☐ Preliminary Amendment ☐ Terminal Disclaimer

☐ Response to Missing Parts Notice ☐ Petition to Commissioner

☐ Resp. to Notice to Correct App. Papers ☐ Status Inquiry

☐ Certified Copy of Priority Doc. ☐ Other \_\_\_\_\_

☐ Claim for Convention Priority

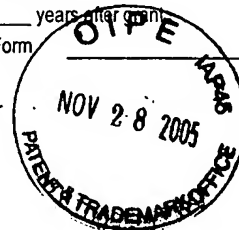
☒ Response/Amendment to Office Action of October 20, 2005

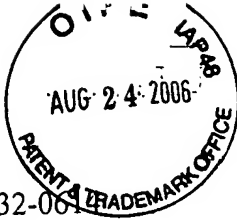
☐ Request for \_\_\_\_\_ month Extension of Time

Check for \$ ☐ Charge Deposit Acct. 500417 \$ Atty Init. AJS Tkpr. # 4236 Secy. or PL: NBelt

CMS Descrip.: \_\_\_\_\_

THE PATENT AND TRADEMARK OFFICE DATE STAMPED HEREON IS ACKNOWLEDGEMENT THAT THE ITEMS, CHECKED ABOVE, WERE RECEIVED BY THE PTO ON THE DATE STAMPED.





Docket No.: 050432-001

**PATENT**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Application of	:	Customer Number: 20277
	:	
Darrell M. ERB, et al.	:	Confirmation Number: 4666
	:	
Application No.: 10/791,904	:	Group Art Unit: 2826
	:	
Filed: March 04, 2004	:	Examiner: Sandvik, Benjamin P.
	:	

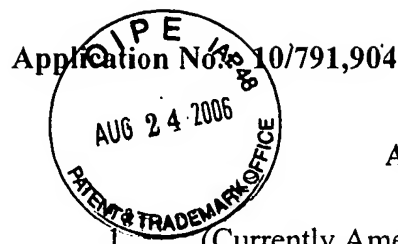
For: COMPOSITE TANTALUM CAPPED INLAID COPPER WITH REDUCED  
ELECTROMIGRATION AND REDUCED STRESS MIGRATION

**AMENDMENT**

Mail Stop Amendment  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Sir:

The following Amendment and Remarks are submitted in response to the Office Action  
dated October 20, 2005.



## AMENDMENTS TO THE CLAIMS

1. (Currently Amended) A semiconductor device comprising:
  - a first dielectric layer over a substrate;
  - copper (Cu) or a Cu alloy, having an upper surface, inlaid in the first dielectric layer; and
  - a composite capping layer on the entire upper surface of the inlaid Cu or Cu alloy, the composite capping layer comprising:
    - a layer of beta ( $\beta$ )-tantalum (Ta) on an upper surface of the inlaid Cu or Cu alloy;
    - a layer of tantalum nitride on the layer of  $\alpha$ -Ta  $\beta$ -Ta; and
    - a layer of alpha ( $\alpha$ )-Ta on the layer of tantalum nitride.
2. (Original) The semiconductor device according to claim 1, wherein the composite capping layer is formed in a recess in the inlaid Cu or Cu alloy such that an upper surface of the  $\alpha$ -Ta layer is substantially coplanar with an upper surface of the first dielectric layer.
3. (Currently Amended) The semiconductor device according to claim 2, wherein:
  - the layer of  $\alpha$ -Ta  $\beta$ -Ta has a thickness of 25Å to 40Å;
  - the layer of tantalum nitride has a thickness of 20Å to 100Å; and
  - the layer of  $\alpha$ -Ta has a thickness of 200Å to 500Å.
4. (Currently Amended) The semiconductor device according to claim 1, wherein:

the layer of  $\alpha$ -Ta  $\beta$ -Ta has a thickness of 25Å to 40Å ;

the layer of tantalum nitride has a thickness of 20Å to 100Å; and

the layer of  $\alpha$ -Ta has a thickness of 200Å to 500Å.

5. (Original) The semiconductor device according to claim 3, further comprising:  
a diffusion barrier lining and opening in the first dielectric layer; and  
the Cu or Cu alloy on the diffusion barrier filling the opening.
6. (Original) The semiconductor device according to claim 3, further comprising:  
a second dielectric layer over the first dielectric layer; and  
Cu or a Cu alloy inlaid in an opening in the second dielectric layer in electrical contact with the upper surface of the  $\alpha$ -Ta layer.
7. (Original) The semiconductor device according to claim 6, further comprising an  $\alpha$ -Ta diffusion barrier lining the opening in the second dielectric layer.
8. (Previously Presented) The semiconductor device according to claim 6, wherein the opening in the second dielectric layer, is a dual damascene opening, and the dual damascene opening is filled with Cu or a Cu alloy forming interconnect comprising a lower via in contact with an upper line.



9. (Previously Presented) The semi-conductor device according to claim 8, further comprising a composite capping layer on the Cu or Cu alloy filling the opening in the second dielectric layer, the composite capping layer comprising:

- a layer of  $\beta$ -Ta on the Cu or Cu alloy;
- a layer of tantalum nitride on the layer of  $\beta$ -Ta; and
- a layer of  $\alpha$ -Ta on the layer of tantalum nitride.

10. (Currently Amended) A method of manufacturing a semiconductor device, the method comprising:

- forming an opening in a first dielectric layer;
- filling the opening with copper (Cu) or a Cu alloy having an upper surface; and
- forming a composite capping layer on the entire upper surface Cu or Cu alloy, the

composite capping layer comprising:

- a layer of beta ( ~~$\alpha$~~ )( $\beta$ )-tantalum (Ta) on an upper surface of the Cu or Cu alloy;
- a layer of tantalum nitride on the layer of  ~~$\alpha$ -Ta~~  $\beta$ -Ta; and
- a layer of alpha ( $\alpha$ )-Ta on the layer of tantalum nitride.

11. (Original) The method according to claim 10, comprising:  
forming a recess in the upper surface of the Cu or Cu alloy before forming the composite capping layer; and

chemical mechanical polishing (CMP) after forming the composite barrier layer such that an upper surface of the  $\alpha$ -Ta layer is substantially coplanar with an upper surface of the first dielectric layer.

12. (Original) The method according to claim 11, comprising forming a diffusion barrier lining the opening before filling the opening with Cu or a Cu alloy.

13. (Currently Amended) The method according to claim 11, comprising:  
forming the layer of  ~~$\alpha$ -Ta~~  $\beta$ -Ta at a thickness of 25Å to 40Å;  
forming the layer of tantalum nitride at a thickness of 20Å to 100Å; and  
forming the layer of  $\alpha$ -Ta at a thickness of 200Å to 500Å.

14. (Currently Amended) The method according to claim 10, comprising:  
forming the layer of  ~~$\alpha$ -Ta~~  $\beta$ -Ta at a thickness of 25Å to 40Å;  
forming the layer of tantalum nitride at a thickness of 20Å to 100Å; and  
forming the layer of  $\alpha$ -Ta at a thickness of 200Å to 500Å.

15. (Currently Amended) The method according to claim 11, comprising depositing the  ~~$\alpha$ -Ta~~  $\beta$ -Ta, titanium nitride and  $\alpha$ -Ta layers by physical vapor deposition (PVD).

16. (Original) The method according to claim 11, further comprising:  
forming a second dielectric layer over the first dielectric layer;  
forming an opening in the second dielectric layer; and

filling the opening in the second dielectric layer with Cu or Cu alloy in electrical contact with the upper surface of the  $\alpha$ -Ta layer of the composite capping layer.

17. (Original) The method according to claim 16, comprising lining the opening in the second dielectric layer with an  $\alpha$ -Ta diffusion barrier layer before filling the opening with Cu or Cu alloy.

18. (Original) The method according to claim 16, wherein the opening is a dual damascene opening, the method comprising filling the dual damascene opening with Cu or Cu alloy to form an interconnect comprising a lower via in contact with an upper line.

19. (Original) The method according to claim 18, further comprising forming a composite barrier layer on the Cu or Cu alloy in the opening in the second dielectric layer, the composite barrier layer comprising:

a layer of  $\beta$ -Ta on the Cu or Cu alloy;

a layer of tantalum nitride on the layer of  $\beta$ -Ta; and

a layer of  $\alpha$ -Ta on the layer of tantalum nitride.

20. (Previously Presented) The semiconductor device according to claim 1, wherein the composite capping layer consists essentially of the layer of  $\beta$ -Ta, the layer of tantalum nitride and the layer of  $\alpha$ -Ta.

21. (Currently Amended) ~~The A semiconductor device according to claim 20,~~  
~~wherein the composite capping layer consists of the layer of  $\beta$ -Ta, the layer of tantalum nitride~~  
~~and the layer of  $\alpha$ -Ta comprising:~~

a first dielectric layer over a substrate;

copper (Cu) or a Cu alloy inlaid in the first dielectric layer; and

a composite capping layer on the inlaid Cu or Cu alloy, the composite capping  
layer consisting of:

a layer of beta ( $\beta$ )-tantalum (Ta) on an upper surface of the inlaid Cu or  
Cu alloy;

a layer of tantalum nitride on the layer of  $\beta$ -Ta; and

a layer of alpha ( $\alpha$ )-Ta on the layer of tantalum nitride.

22. (Previously Presented) The semiconductor device according to claim 1, wherein  
the layer of  $\alpha$ -Ta has a thickness of 200Å to 500Å.

23. (Previously Presented) The method according to claim 10, wherein the composite  
capping layer consists essentially of the layer of  $\beta$ -Ta, the layer of tantalum nitride and the layer  
of  $\alpha$ -Ta.

24. (Currently Amended) ~~The A method according to claim 23, wherein the~~  
~~composite capping layer consists of the layer of  $\beta$ -Ta, the layer of tantalum nitride and the layer~~  
~~of  $\alpha$ -Ta~~ of manufacturing a semiconductor device, the method comprising:

forming an opening in a first dielectric layer;

filling the opening with copper (Cu) or a Cu alloy; and

forming a composite capping layer on the Cu or Cu alloy, the composite capping layer consisting of:

a layer of beta ( $\beta$ )-tantalum (Ta) on an upper surface of the Cu or Cu

alloy;

a layer of tantalum nitride on the layer of  $\beta$ -Ta; and

a layer of alpha ( $\alpha$ )-Ta on the layer of tantalum nitride.

25. (Previously Presented) The method according to claim 10, comprising forming the layer of  $\alpha$ -Ta has a thickness of 200Å to 500Å.

## REMARKS

Claims 1 through 25 are pending in this Application. Claims 1, 3, 4, 8 through 10, 13 through 15, 21 and 24 have been amended. Care has been exercised to avoid the introduction of new matter. Indeed, adequate descriptive support for the present Amendment should be apparent throughout the originally filed disclosure as, for example, Fig. 2C and the related discussion thereof in the written description of the specification. Applicants note that typographical oversights have been corrected in claims 1, 3, 4, 8, 9, 10, 13, 14, 15, and that claims 21 and 24, indicated allowable, have been placed in independent form. Applicants submit that the present Amendment does not generate any new matter issue.

### **Claim objections.**

The Examiner objected to claims 3, 4, 13 and 14 identifying an informality. By the present Amendment the identified informality has been addressed, thereby overcoming the stated bases for the claim objections. Accordingly, withdrawal of the objections to claims 3, 4, 13 and 14 is solicited.

**Claims 1, 4, 10, 14, 20, 22, 23 and 25 were rejected under 35 U.S.C. § 103 for obviousness predicated upon Nogami et al. in view of Seet et al.**

In the statement of the rejection the Examiner concluded that one having ordinary skill in the art would have been motivated to form the interconnect structure of Nogami et al. by forming a beta-Ta layer on the inlaid copper and forming an alpha-Ta layer on the titanium nitride layer in view of Seet et al. This rejection is traversed.

Independent claims 1 and 10 have been clarified by reciting that the capping layer is on the entire upper surface of the inlaid copper or copper alloy. No such structure is disclosed by Nogami et al. This is because the composite layer pointed to by the Examiner is **not** a capping layer, but an interconnect between copper and aluminum. Clearly, the composite capping layer identified by reference characters 13, 14, 15 and 16 in Fig. 1 of Nogami et al. is **not** formed on the entire upper surface of the inlaid copper. Nor is there any reason apparent from the record why one having ordinary skill in the art would have **deviated** from the teachings of Nogami et al. and have been led to form the composite capping layer over the entire upper surface of the inlaid copper, apart from Applicants' disclosure. Applicants' disclosure is, of course, forbidden territory upon which the Examiner may excavate for the requisite motivational element. *Panduit Corp. v. Dennison Mfg. Co.*, 774 F.2d 1082, 227 USPQ 337 (Fed. Cir. 1985).

The secondary reference to Seet et al. does not cure the argued deficiencies of Nogami et al., because Seet et al. have nothing to do with an interconnection between copper and aluminum. Accordingly, even if the structure and method of Nogami et al. are modified as suggested by the Examiner, and Applicants do not agree that the requisite fact-based motivation has been established, the claimed invention would not result. *Uniroyal, Inc. v. Rudkin-Wiley Corp.*, 837 F.2d 1044, 5 USPQ2d 1434 (Fed. Cir. 1988).

Applicants, therefore, submit that the imposed rejection of claims 1, 4, 10, 14, 20, 22, 23 and 25 under 35 U.S.C. § 103 for obviousness predicated upon Nogami et al. in view of Seet et al. is not factually or legally viable and, hence, solicit withdrawal thereof.

**Claims 2, 3, 5 through 8, 11 through 13 and 16 through 18 were rejected under 35 U.S.C. § 103 for obviousness predicated upon Nogami et al. in view of Seet et al. and Sudijono et al.**

In the statement of the rejection the Examiner concluded that one having ordinary skill in the art would have been motivated to form the composite layer of Nogami et al. in a recess in the inlaid copper in view of Sudijono et al. This rejection is traversed.

Firstly, claims 2, 3 and 5 through 10 depend from independent claim 1, and claims 11 through 13 and 16 through 18 depend from independent claim 10. Applicants incorporate herein the arguments previously advanced in traversing the imposed rejection of claims 1 and 10 under 35 U.S.C. § 103 for obviousness over Nogami et al. in view of Seet et al. The additional reference to Sudijono et al. does not cure the previous argued deficiencies in the attempted combination of Nagami et al. and Seet et al.

Furthermore, Applicants separately argue the patentability of claims 2, 3, 5 through 8, 11 through 13 and 16 through 18. As previously pointed out, Nogami et al. **do not form a capping layer**, as that term would have been understood by one having ordinary skill in the art, on any inlaid copper. Nogami et al. merely form an interconnection between copper and aluminum. Element 16 in the Fig. 8 structure of Sudijono et al. is **not**, repeat **not**, an interconnect between copper and aluminum as is the composite layer of Nogami et al. relied upon by the Examiner. Accordingly, regardless of what Sudijono et al. may or may not teach about inlaying a capping layer, such a teaching would not apply to the interconnect of Nogami et al. It makes no sense to imbed the composite interconnect of Nogami et al.

Again, the Examiner has not factually established that one having ordinary skill in the art would have recognized the composite interconnect layer of Nogami et al. functions as a capping



layer, and it cannot because it is not intended to perform that function and is not formed across the upper surface of the inlaid copper. Accordingly, what may or may not be conventional practice with respect to capping layers has **no applicability** to the interconnect structure of Nogami et al.

Applicants, therefore, submit that the imposed rejection of claims 2, 3, 5 through 8, 11 through 13 and 16 through 18 under 35 U.S.C. § 103 for obviousness predicated upon Nogami et al. in view of Seet et al. and Sudijono et al. is not factually or legally viable and, hence, solicit withdrawal thereof.

**Claims 9 and 19 were rejected under 35 U.S.C. § 103 for obviousness predicated upon Nogami et al. in view of Seet et al., Sudijono et al. and Gupta et al.**

In the statement of the rejection the Examiner concluded that one having ordinary skill in the art would have been motivated to provide a second composite capping layer over the inlaid copper of the structure disclosed by Nogami et al. in view of Gupta et al. This rejection is traversed.

Firstly, claims 9 and 19 depend from independent claims 1 and 10, respectively. Applicants incorporate herein the arguments previously advanced in traversing the imposed rejection of claims 1 and 10 under 35 U.S.C. § 103 for obviousness predicated upon Nogami et al. in view of Seet et al. The additional references to Sudijono et al. and Gupta et al. do not cure the previously argued deficiencies in the attempted combination of Nogami et al. and Seet et al.

Further, Applicants separately argue the patentability of claims 9 and 19. The Examiner's proposed modification of Nogami et al. would render the entire invention of Nogami et al. **inoperative**. Nogami et al. seek to interconnect copper and aluminum. Nogami et al. do **not**

seek to interconnect copper and copper which is what Gupta et al. do. The Examiner's arbitrary surgical extraction of a portion of Gupta et al., relating to copper-copper interconnects and impressing that surgically extracted section into the structure of Nogami et al. which relates to a copper-aluminum interconnect, is without any factual basis or technological rationale.

Based upon the foregoing Applicants submit that the imposed rejection of claims 9 and 19 under 35 U.S.C. § 103 for obviousness predicated upon Nogami et al. in view of Seet et al., Sudijono et al. and Gupta et al. is not factually or legally viable and, hence, solicit withdrawal thereof.

**Claim 15 was rejected under 35 U.S.C. § 103 for obviousness predicated upon Nogami et al. in view of Seet et al., Sudijono et al. and Lopatin et al.**

This rejection is traversed.

Claim 15 depends from independent claim 10. Applicants incorporate herein the arguments previously advanced in traversing the imposed rejection of claim 10 under 35 U.S.C. § 103 for obviousness predicated upon Nogami et al. in view of Seet et al. The additional references to Sudijono et al. and Lopatin et al. do not cure the previously argued deficiencies in the attempted combination of Nogami et al. and Seet et al.

Applicants, therefore, submit that the imposed rejection of claim 15 under 35 U.S.C. § 103 for obviousness predicated upon Nogami et al. in view of Seet et al., Sudijono et al. and Lopatin et al. is not factually or legally viable and, hence, solicit withdrawal thereof.

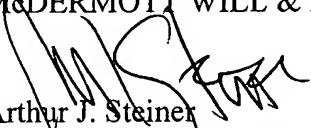
Applicants acknowledge, with appreciation, the Examiner's indication that claims 21 and 24 would be allowed upon overcoming the imposed rejections under the second paragraph of 35

U.S.C. § 112. Applicants note that the Examiner did not impose a rejection under the second paragraph of 35 U.S.C. § 112. Presumably, the Examiner intended to refer to the objection to the claims, which was overcome. Based upon the foregoing it should be apparent that not only the imposed objection but the imposed rejections have been overcome, and that all pending claims are in condition for immediate allowance. Favorable consideration is, therefore, solicited.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

McDERMOTT WILL & EMERY LLP

  
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**Date: November 28, 2005**

**Please recognize our Customer No. 20277  
as our correspondence address.**